Comparative Effect of Yoga and Meditation on Mathematical Abstraction Abilities: A Serial Mediation Analysis with Working Memory and Mind Wandering

Synopsis

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1.0 Introduction

Mathematics is often said to be difficult because it deals with abstractions. However, abstraction is indigenous to everyday human reasoning. Indeed, abstraction and the ability for abstraction are innate properties of the human mind (Devlin, 2000). From calculating a grocery bill to launching rockets to Mars, mathematics is used to predict and control real-world objects and events. Abstraction plays a crucial role in simplifying complex problems and developing general theories and methods. Many students have difficulty making sense of abstract mathematical concepts and relations (Mitchelmore, 2002). A study revealed that high school students' reason for disliking mathematics is not having the confidence to have deep content mathematical knowledge (Aguilar, 2021). According to the Sustainable Development Goal 4 report published by UNESCO, a mere 12.3 percent of students in India's lower secondary schools, aged 10-16, demonstrate proficiency in fundamental mathematical concepts (Benu, 2022). Despite India's projection that 65 percent of its lower secondary graduates will possess a minimum level of mathematical proficiency by the year 2025 and 75 percent by 2030, the current figure falls significantly short when compared to neighbouring countries such as Pakistan, Sri Lanka, Bangladesh, and Nepal (Benu, 2022). The situation is particularly disconcerting at the higher echelons of education, as the Central Board of Secondary Education (CBSE) affirms that a mere 21% of students who complete their 10th-grade education choose to pursue mathematics at the senior secondary level (Thakur, 2020). The ability for abstraction possesses the potential to enhance the foundational understanding of students in the realm of mathematical education (Nurjannah and Kusnandi, 2021). The comprehension of mathematical concepts poses an intricate and challenging task for analysis, given its interplay with different cognitive processes (Dreyfus, 2002). Psychologists and maths educators have been investigating the elements and cognitive processes associated with understanding mathematical notions and concepts.

1.1 Mathematical Abstraction Ability

Mathematical abstraction is the process of extracting the underlying structures, patterns, or properties of a mathematical concept, removing any dependence on real world objects with which it might originally have been connected, and generalising it so that it has wider applications or matches among other abstract descriptions of equivalent phenomena (Russell; Ash, 1998).

Turning concrete objects into abstract concepts involves varied and less defined routes in the brain. Different types of abstractions share a logical similarity by extracting essential features, but their physical processing is influenced by specific contexts (Gilead et al., 2014). For instance, visual information abstraction occurs in the brain's ventral stream (Quiroga et al., 2005), social information in the medial prefrontal cortex (Mitchell et al., 2006), and mathematical knowledge in the parietal lobe (Cohen et al., 2000).

A recent meta-analysis suggests that abstract concepts elicit greater brain activity in the inferior frontal gyrus and middle temporal gyrus compared to concrete concepts. These results suggest greater engagement of the verbal system for processing abstract concepts (Wang et al., 2010). Another study identifies the prefrontal cortex as the brain region responsible for abstract thinking, specifically in applying rules about "same" and "different" to various images. Research shows that neurons in the prefrontal cortex can encode abstract rules, indicating their role in cognitive control and decision-making processes (Conway, 2001).

Many branches of mathematics originated from the examination of practical problems in the physical world before the discovery and establishment of fundamental principles and ideas. Subsequently, these principles and ideas were formulated as abstract structures (Wiggins, 2018). For instance, the solution to arithmetic problems gave rise to algebra, a fundamental branch of mathematics that uses letters and other universal symbols to represent numbers and quantities in formulas and equations. Similarly, the development of geometry can be traced back to the efforts of individuals striving to resolve real-world problems related to distances and areas. The process of moving from the concrete to the abstract scenario is known as abstraction. These concepts are often tough to visualise and can be quite difficult to learn. This means students need a degree of mathematical maturity to process the shift from the concrete to the abstract.

The challenges encountered during the transition to university, specifically the disparity between school-level and university-level mathematics, are widely considered to be a significant factor contributing to a notable increase in the rates of students abandoning their pursuit of mathematics studies (Huesel et al., 2023). While school mathematics is application-oriented, academic mathematics has a theoretical character and focuses on proof (Hoyles et al., 2001; Engelbrecht, 2010). Various research investigations

have highlighted the prevailing decline in the number of students who are enrolled in advanced mathematics. (Ainley et al., 2008; Chinnappan et al., 2008; Forgasz, 2006). As the enrollment of students in advanced mathematics courses experienced a substantial decrease, there has been a rise in the enrollment of students lacking mathematical preparedness in undergraduate courses, which has led to reductions in enrollments and low rates of success in institutes of higher education (Nicholas et al., 2015).

The role of abstraction ability is of great significance due to its close correlation with the establishment of fundamental mathematical concepts. These concepts serve as prerequisites for acquiring new material in the realm of mathematics education (Nurjannah and Kusnandi, 2021). Furthermore, students' acquisition of this ability enables them to effectively recognise problems and propose solutions based on their existing knowledge. Algebra serves as an initial introduction for students to the realm of abstract mathematical reasoning. Consequently, it poses considerable challenges for those students who continue to engage in concrete reasoning (Susac et al., 2014). The National Mathematics Advisory Panel (NMAP) highlighted the importance of conducting longitudinal research to ascertain the early indicators of success or failure in the field of algebra (p. 33). The expectation is that by identifying these indicators, it will be possible to inform the development of interventions aimed at fostering the fundamental skills required for achievement in algebra, which allows students to develop abstract mathematical cognition. Nonetheless, the investigation only revealed a limited number of studies that have explored the predictors of algebraic performance (Fuchs, 2016).

1.2 Yoga

Yoga is a spiritual discipline grounded in a profoundly intricate realm of study that revolves around attaining a balance between the cognitive and corporeal dimensions of an individual's existence. It constitutes a mode of creative manifestation and a systematic methodology for upholding a condition of optimal health (Basavaraddi, 2015). The physical yoga discipline includes asanas (postures), pranayama (breathing techniques), and dhyana (meditation) (Iyengar et al., 1996). Yoga is often understood as a remedial or corporeal conditioning regimen. While yoga naturally promotes physical and mental well-being, its objectives go beyond this narrow scope (Yadav et al., 2022).

A meta-analysis demonstrates that yoga has a significant influence on various aspects of cognitive ability

in individuals with sound physical conditions, namely concentration and information processing, executive function, and memory (Gothe & Edward, 2015). Studies reported significant effects of the yoga-based intervention on cognition from pre-to-post intervention (Pandya, 2018; Hariprasad et al., 2013; Gothe et al., 2014; Voss et al., 2022). No significant effects of the yoga-based intervention were found on cognitive functions or alertness measures (Oken et al., 2006; Cekanauskaite et al., 2020). So, studies conducted on yoga-based interventions have found contradictory results, which are yet to be confirmed by further studies (Hoy et al., 2021).

The findings of a research study demonstrate that individuals who engaged in the practice of yoga experienced enhancements in their academic performance, physical well-being, and psychological state while concurrently reducing the occurrence of their cognitive processes (Kauts & Sharma, 2009). Yoga practices yield noteworthy advancements in the academic performance of secondary-level students in the field of mathematics. This is achieved through the augmentation of concentration, memory, and cognitive function, thereby fostering an enriched learning experience for individuals (Kushwaha, 2016). However, yoga appears to offer potential psychological benefits through the inclusion of mindfulness training, which encompasses the practice of meditation (Mehling, 2018). Incorporating meditative elements in yoga fosters the advancement of cognitive function, specifically working memory, although the underlying mechanism is yet to be clarified (Bruner et al., 2017).

1.3 Meditation

The term “meditation” refers to a variety of practices that focus on mind and body integration and are used to calm the mind and enhance overall well-being. It is an umbrella term that encompasses a huge number of diverse practices (Matko & Sedlmeier, 2019). Some types of meditation involve maintaining mental focus on a particular sensation, such as breathing, a sound, a visual image, or a mantra, which is a repeated word or phrase. Other forms of meditation include the practice of mindfulness, which involves maintaining attention or awareness of the present moment without making judgements.

Meditation is a practice that involves training the mind to achieve a state of calmness and clarity. Meditation involves the practice of mindful observation, which emphasises the role of embodied cognition in meditation (Matko & Sedlmeier, 2019). Meditation is a technique that helps individuals relax their body and mind, as well as free their minds from unnecessary thoughts and brain activity

(Pathath, 2017).

Regular meditation practice can improve concentration and focus by training the mind to stay present and avoid distractions. Research suggests that meditation can enhance cognitive abilities, such as attention, memory, and decision-making. (Pathath, 2017; Sharma, 2015). Meditation can help students achieve an elevated state of awareness and focused attention, which can enhance their learning and academic performance (Sidhu, 2022). Across various research studies, the participants exhibited a decrease in mind-wandering and mindless reading after engaging in meditation training (Zanesco et al., 2016). It is possible that intensive meditation training could facilitate a decrease in mind-wandering for individuals who need to sustain their attention during a complex cognitive task. Research suggests that meditation induces plasticity in the brain, leading to structural and functional changes that can enhance learning and cognitive abilities (Davidson & Lutz, 2008; Holzel et al., 2011). Mindfulness meditation, in particular, has been shown to increase the thickness of the prefrontal cortex and hippocampus, which are involved in attention and memory processes (Kozasa et al., 2012; Deepeshwar et al., 2015).

The impact of meditation on mathematical accomplishments has not been directly examined by researchers. However, they have proposed psychological advantages of meditation that may enhance performance in mathematics. From the results of the research, it can be inferred that meditation is seen as a means to enhance the consciousness and mental clarity of mathematicians, potentially leading to improved focus, creativity, and problem-solving abilities in mathematical research. However, it is suggested that the relationship between meditation and mathematics is an area that requires more exploration (Gorini & Runkle, 2023).

1.4 Working Memory

Working memory refers to the mental capacity to temporarily store and process a limited amount of information to complete ongoing cognitive tasks (Wen & Jackson, 2022). It is a cognitive system that allows individuals to hold information in their minds while simultaneously manipulating and using that information to perform tasks. Working memory skills are linked to key learning outcomes, including reading and math (Alloway & Copello, 2013), and play an important role in learning from kindergarten to the college years. The processes underlying working memory are essential for various cognitive activities, such as reasoning tasks, verbal comprehension, and mathematical skills (Cowan & Alloway,

2008). Working memory skills are particularly important in complex mathematical tasks that require holding multiple pieces of information in mind and making connections between them. Individuals with stronger working memory tend to perform better in mathematical tasks and have a better understanding of mathematical concepts (Alloway & Copello, 2013).

The most popular model of working memory is the multicomponent model proposed by Baddeley and Hitch, which includes a central executive and three sub-systems: the phonological loop, visuospatial sketchpad, and episodic buffer (Baddeley and Hitch, 1974; Baddeley, 2000, 1992, 1986; Baddeley and Della Sala, 1996). Significant associations between working memory components and learning have also been established (Peng et al., 2018; Juniati & Budayasa, 2020), especially in mathematics (Adams & Holmes, 2006; Allen et al., 2019).

Some researchers emphasise the possibility of training working memory to improve learning and education. (Alloway & Copello, 2013; Cowan, 2013; Ei & Oo, 2023). Training working memory can enhance cognitive abilities, academic performance, and the acquisition of new knowledge and skills, making it a valuable tool in the learning process. Working memory training can be achieved through various interventions, including mindfulness exercises, physical activities, mnemonic devices, teaching strategies, and computerised programmes (Ei & Oo, 2023). Individuals with reduced working memory capacity are particularly susceptible to the occurrence of mind wandering, which has the potential to detrimentally affect their cognitive task performance, as their executive-control systems may frequently fail to keep thoughts task-focused (Kane, 2012).

1.5 Mind Wandering

Mind wandering refers to the phenomenon where our thoughts drift away from the current task or focus and become unrelated to the ongoing events or activities. Mind wandering can happen spontaneously and involuntarily, often without our awareness (Zheng et al., 2019). Some of the primary attributes employed to depict MW are task-unrelated thoughts (Smallwood & Schooler, 2006; Giambra, 1989), stimulus-independent thoughts (Antrobus, 1968; Stawarczyk et al., 2011), or a dynamic and unconstrained flow of thoughts (Christoff et al., 2016). There are two forms of mind wandering: spontaneous and voluntary (Carriere et al., 2013; Seli et al., 2016), with the former being an involuntary shift of attention and the latter being a conscious choice to stop focusing on the task at hand; spontaneous

mind wandering is linked to executive control failure (McVay et al., 2008) and high distractibility (Chiorri & Vannucci, 2019; Vannucci et al., 2020), while voluntary mind wandering is associated with diminished motivation (Robinson & Unsworth, 2017; Seli et al., 2015).

It has been associated with various outcomes, both positive and negative. On the positive side, mind wandering has been linked to functions such as planning and creativity (Baird et al., 2011; 2012). However, it can also have negative consequences, including impaired performance in daily life, affective dysfunction, working inefficiency, and even accidents, including while driving (McVay et al., 2009; Smallwood et al., 2003; Killingsworth and Gilbert, 2010; Farley et al., 2013; Seli et al., 2016; Yanko and Spalek, 2013).

It is often described as a divergent mental state that can have a detrimental effect on cognitive performance (Vago & Zeidan, 2016). Individuals possessing a lower working memory capacity (WMC) are generally more prone to experiencing episodes of mind wandering and performing poorly on intellectual (Kane & McVay, 2012). While mind-wandering does possess the potential to serve advantageous purposes, it is concurrently correlated with a decline in task and activity performance (Pachai et al., 2016). The bidirectional nature of the association between working memory and mind wandering is evident (Kane & McVay, 2012). This is because the capacity of working memory can influence both the frequency and intensity of mind wandering. Conversely, mind wandering is also capable of impacting the performance of working memory (Kane & McVay, 2012). This is because the act of mind wandering can disrupt the performance of working memory by diverting attention away from the current task and reducing the individual's capacity to both maintain and manipulate information within their working memory (Kane & McVay, 2012).

The negative link between mind wandering and learning outcomes has predominantly been observed (Caruso et al., 2023). These findings suggest that interventions to address mind wandering during learning could be beneficial in improving learning outcomes. Mindfulness practices, such as meditation, help individuals develop greater awareness of their thoughts and emotions, allowing them to recognise when their mind starts to wander. This increased awareness enables individuals to redirect their attention back to the present moment, reducing mind wandering (Mrazek et al., 2013). Short-term engagement in yoga activities has the potential to enhance the function of attention control, alleviate mind wandering,

and mitigate negative emotional states, including anxiety and tension (Suzuki et al., 2021).

Research in cognitive neuroscience has advanced the understanding of mind wandering with the discovery of the default mode network on the medial surface of the cortex (Greicius et al., 2003; Raichle et al., 2001). This network is active during mind wandering, leading to perceptual decoupling, a disengagement from external events (Mason et al., 2007; McKiernan et al., 2003, 2006; Andrews-Hanna et al., 2014; Smallwood & Schooler, 2014). Mind wandering is also described as a state of decoupled attention where individuals direct their attention towards their own private thoughts and feelings instead of processing information from the external environment (Smallwood et al., 2007). This shift in attention reorganises cognition to focus on intrinsic thoughts (Kam & Handy, 2013) and reduces attention to the external environment (Smallwood, 2013a). This causes transient self-generated states to persist and lead to errors on demanding tasks (Smallwood, 2013a). Evidence for perceptual decoupling comes from studies examining the temporal relationship between self-generated thought and cortical processing of external information, characterised by quantified evoked responses like event-related potentials (ERPs) from the EEG (Smallwood & Schooler, 2014).

The measurement of mind wandering can broadly be categorised as behavioural, neurological, and physiological. Behavioural measurements may include self-reported assessments like questionnaire methods, verbal reports, and objective indicator support methods like SART (Sustaine Attention to Response Task) (Xie & Xu, 2024); neurological measurements could involve brain imaging techniques like EEG, fMRI, and MEG; and physiological measurements include eye tracking to investigate brain activity patterns, connections to cognitive performance, and neurological processes behind individual mind wandering. (Waters et al., 2014; Xie & Xu, 2024).

The present study will be limited to the behavioural measurement of mind wandering. Subjective methods like self-reports and subjective experiences, which can be influenced by biases or inaccuracies, lack objectivity. The SART (Sustained Attention Response Task) is a commonly used behavioural indicator in mind wandering research, providing objective measurements of subjects' cognitive states during tasks (Xie & Xu, 2024).

2.0 Emergence

According to a 2019 report published in the Economic Times, renowned mathematicians believe India

needs to improve its mathematics capabilities to effectively use data analytics, artificial intelligence, and machine learning technologies for innovative and robust solutions.

Manjul Bhargava, a mathematics professor at Princeton University, emphasises the importance of strong mathematical talent for India to lead the fourth industrial revolution. Srinivasa Varadhan, a mathematics professor at New York University, highlights the role of maths in guaranteeing the effectiveness of machine learning algorithms and determining under what circumstances they would work (Phadnis & John, 2019).

The decline in maths education is a global phenomenon, and India, despite inventing zero, has also suffered from this decline. Studies have claimed that mathematics is an indispensable tool for any nation's development and scientific innovations (Said & Gadde, 2023; Chand et al., 2021). Mathematical modelling based on abstraction is a widely used tool in major scientific research, inventions, and applications. Mathematical modelling remains at the forefront of scientific and engineering endeavours, unlocking new avenues of exploration and innovation (Ortiz, 2023). Abstraction plays a crucial role in mathematical modelling, as it allows for the representation of complex phenomena in a simplified and manageable way (Zamecnik, 2018). Abstraction involves simplifying complex real-world systems into mathematical models that capture the essential features and relationships (Ortiz, 2023)

Mathematical subjects like calculus, real analysis, linear algebra, topology, and category theory are very advanced examples of abstraction. These concepts are often tough to visualize and can be quite difficult to learn (Wiggings, 2018). Many students have difficulty making sense of abstract mathematical concepts and relations (Mitchelmore, 2002). Studies claimed that the number of students enrolling in higher-level mathematics courses had declined significantly (as cited in Chand, 2021). Studies have highlighted the downward trend in the number of students enrolled in advanced mathematics (Ainley et al., 2008; Chinnappan et al., 2008; Forgasz, 2006). There is a growing body of correlational and experimental evidence demonstrating associations between general cognitive skills and proficiency with specific components of mathematics (e.g., number fact knowledge, algebraic thinking) (Gilmore, 2023). Evidence demonstrates the impact of metacognitive awareness on the acquisition of mathematics learning (Bae and Kwon, 2021). Physical exercise has been associated with improved cognitive function, particularly in areas such as executive function and memory (Dinius et al., 2023).

Meditation practices, like mindfulness meditation, can enhance attention and focus, reduce stress and anxiety, increase working memory capacity, and improve brain structure and function. These practices help individuals redirect their attention to the present moment, reduce mind-wandering, and enhance self-regulation skills (Brefczynski et al., 2007; Carter et al., 2005; Lazar et al, 2005; Pagnoni and Cekic, 2007; Lutz et al., 2007; Srinivasan and Baijal, 2007). Meditation can also lead to changes in brain structure and function, such as increased grey matter volume in regions involved in attention and memory processes (Pagnoni & Cekic, 2007). The practice of yoga is thought to enhance cognitive functioning and promote a state of mindfulness (Bruner et al., 2017).

Yoga is a practice that has gained significant interest in recent years for its potential cognitive benefits. It involves a combination of physical postures, breathing exercises, and meditation techniques. Yoga is believed to improve cognitive functioning and enhance mindfulness (Bruner et al., 2017). According to The Yoga Sutras of Patanjali, verse 1.2, "Yoga is the ability to harness the wandering mind by practising complete focus towards harmony and clarity by the individual" (Stone, 2019). There is a significant difference in cognitive functions between those who practice and those who do not practice yoga (Verma et al., 2022). A study on adolescents discovered that those who practise yoga have improved concentration and short-term memory (Kauts & Sharma, 2012). The results of a study indicate that students who practiced yoga improved their academic performance, physical health, & psychological well-being, and decreased their frequency of thought (Kauts & Sharma, 2009). Yoga practices significantly improve secondary-level students' mathematics academic performance, enhancing concentration, memory, and cognitive function, and thus enhancing their learning experience (Kushwaha, 2016). The meditative aspect of yoga practice may contribute to the enhancement or improvement of working memory, although the mechanism is yet to be clarified (Bruner et al., 2017). Yoga and meditation have complementary benefits that enhance overall well-being.

Meditation is the training of the mind to achieve a state of calmness and clarity. Meditation has been found to improve cognition and help school students in academics. It enhances cognitive functioning, attention, working memory, and executive function, which are all important for academic performance (Delavari et al., 2023: Liu et al., 2022). Meditation can have numerous benefits, including reducing stress levels, improving cognitive function, enhancing emotional well-being, and promoting overall

mental and physical health (Lemay et al., 2019). Some researchers have suggested that scientific studies should be able to determine how much the meditation technique improves mathematical aptitude; some of these studies have produced interesting results regarding this improvement. (see Nidich et al., 2011; Nidich and Nidich, 1989), as cited in Gorrini et al., 2023. A 2-week course focusing on posture, focused-attention meditation, breathing, and mental relaxation improved attention, reduced mind wandering, and improved learning (Mrazek et al., 2013). Evidence has found that 8 weeks of brief, daily meditation practice resulted in improved attention, working memory, and recognition memory compared to the control group (Basso et al., 2018). Single-bout focused-attention meditation training has been associated with improved working memory performance (Deng et al., 2021).

The practice of yoga and meditation has been shown to enhance the volume of grey matter in specific brain regions, resulting in improved cognitive function. Additionally, it has been found to increase the thickness of the cerebral cortex, leading to enhanced cognitive abilities (Luders et al., 2009; Vestergaard et al., 2009).

Working memory is a cognitive ability that plays a crucial role in tasks such as speech comprehension, arithmetic, learning, and complex reasoning. It forms the basis of all learning experiences (Gathercole & Alloway, 2004) and enables incoming information to be combined with old information, associated with, and transformed into new information for learning to take place (Swanson & Beebe-Frankenberger, 2004; Swanson & Saez, 2003). Students with poor working memory capacity will often struggle with academics, leading to poor academic progress (Alloway, 2006). Working memory is important in many areas of academics, and extensive research has connected working memory to performance, specifically in mathematics. A negative correlation has been found between working memory and students' mathematical learning difficulties (Nur et al., 2018). Working memory plays a role in the cognitive aspects of mathematics, influencing attitudes towards mathematics and performance in mathematical tasks (Dowker et al., 2022; Cakir et al., 2022). Individuals with lower working memory capacity are more likely to experience mind wandering and perform poorly on intellectual tasks (Kane, 2012). A research inquiry into the cognitive mechanisms that underlie a wandering mind reveals the involvement of working memory, a cognitive system that functions as a mental realm for managing multiple thoughts at the same time (Sakai, 2012).

Mind wandering can serve adaptive functions but is also associated with decreased performance in tasks and activities. Mind wandering refers to the involuntary drifting of thoughts away from the current task or activity, which can have both positive and negative effects on performance and cognitive functioning (Kane, 2012). People engage in mind-wandering when their self-generated cognitions prompt redirection of their attentional focus away from the task at hand towards their internal thoughts and emotions (Smallwood and Schooler, 2015). Although mind wandering is an inherent tendency of the human psyche, it exerts an adverse influence on tasks that require sustained attention. Mind wandering or task-unrelated thoughts can impact comprehension during lectures and reading, potentially hindering academic success (Lindquist & McLean, 2011; Risko et al., 2012; Szpunar et al., 2013). Mind wandering is a probable factor in the low achievements in mathematical performance (Randall et al., 2019). It has previously been noted that meditation is a promising tool for enhancing attention span and explaining the mechanism of attention control (Lutz et al., 2004, 2009; Tang et al., 2007; Brewer et al., 2011). Investigations into the impact of intensive meditation training on mind wandering have also indicated that such training diminishes the tendency of the mind to wander, resulting in longer periods of meditative absorption and improved attentional performance (Brandmeyer and Delorme, 2016; Zanesco et al., 2016).

School-based yoga and meditation programmes have a positive impact on students' academic performance by promoting a relaxed state of being (Dai et al., 2015), bringing students into the present moment (Eastman-Mueller et al., 2013; Wang & Hagins, 2016), and enhancing executive function (Best, 2010; Diamond & Lee, 2011; Fumoto et al., 2010; Ratey, 2013). Meditation training leads to improved information quality and reduced response conservativeness, with no changes in non-decisional factors (Wagenmakers et al., 2007). It has been suggested to investigate the potential transfer effects of meditation on other cognitive domains. This can provide a broader understanding of the cognitive benefits of meditation (Deng et al., 2021). Research into school meditation programmes is still in its infancy, with only a few published studies examining the relationship between meditation and academic achievement. More research is needed to understand the underlying mechanisms through which meditation impacts student outcomes and to enhance the effectiveness of meditation interventions in schools (Waters et al., 2015).

A study has shown significant improvement in working memory task scores following the two yoga-based relaxation techniques (cyclic meditation and supine rest) (Subramanya & Telles, 2009). Short-term yoga practice can lead to a decrease in mind wandering and improve attention control function (Suzuki, 2021). A brief yoga programme can enhance both working memory and mindfulness, but further research is needed to understand the extent of yoga-related cognitive enhancement and the underlying mechanisms (Bruner et al., 2017).

Based on the aforementioned evidence, training like yoga and meditation has been shown to improve working memory capacity and decrease mind wandering, leading to improved cognitive performance. Such training may also reduce distracting thoughts during mathematical tasks, allowing individuals to stay focused on the task at hand. Therefore, by improving working memory and reducing mind wandering, individuals may enhance their ability to understand and solve abstract mathematical concepts.

Hence, the present study aims to identify the effect of yoga and meditation on the mathematical abstraction ability of secondary school students. Also to investigate the role of underlying mediators that can intervene in the above relationship through working memory and mind wandering.

3.0 Justification

Mathematical abstraction is a fundamental and supportive ability for the formation of mathematical concepts. The ability for abstraction can potentially enhance students' initial understanding of the acquisition of mathematical knowledge (Nurjannah & Kusnandi, 2021). Abstraction involves the process of constructing new structures and finding new concepts or strategies that can be used in solving problems. Studying mathematical abstraction can provide insights into the cognitive processes involved in students' learning and help educators design effective instructional strategies. Overall, addressing mathematical abstraction at the secondary school level can enhance students' mathematical thinking and problem-solving abilities, as well as improve the quality of mathematics education.

Investigating the effectiveness of interventions like yoga and meditation on the mathematical abstraction abilities of secondary school students is necessary for several reasons. Evidence suggests that mindfulness-based interventions, including yoga, can improve cognitive functioning in children and adolescents (McCurdy et al., 2023). This includes attention and memory, which are important skills for

mathematical abstraction. Yoga-based practices focusing on pranayama and relaxation meditation can improve cognitive flexibility, which is associated with effective problem-solving and decision-making (Pandey & Dagar, 2022). This indicates that there may be cognitive processes or mechanisms that are influenced by yoga-meditation interventions and contribute to improved mathematical abstraction abilities. Further research is needed to explore the specific cognitive mediators that link yoga-meditation interventions to mathematical abstraction abilities, which could provide valuable insights into the underlying mechanisms of these interventions and their impact on cognitive functioning.

The present study will contribute to the growing scientific interest in the effects of meditation practices and yoga-based interventions on brain function and behaviour. It provides compelling evidence that mind-body practices like meditation and yoga are associated with improvements in cognitive processes and abilities. An intervention focused on yoga and meditation will assist in improving cognitive abilities like working memory, giving greater mental resources to process mathematical abstraction. It has also been hypothesised that such intervention can help to attain focus on the task at hand by reducing task-unrelated mind wandering, which in turn helps to increase the mathematical abstraction ability of secondary school students. The research will try to investigate the comparative effect of yoga and meditation practices on mathematical abstraction ability through working memory and mind-wandering.

4.0 Statement of the Problem

Comparative effect of yoga and meditation on mathematical abstraction abilities: A serial mediation analysis with working memory and mind wandering.

5.0 Variables

- **Independent Variable:** Yoga and Meditation
- **Dependent Variable:** Mathematical Abstraction Ability
- **Mediating Variables:** Working Memory and Mind Wandering

6.0 Definition of Variables

6.1 Yoga

Yoga is the science of conditioning the mind and body through various practices such as shatkarma, asana, pranayama, mudra, and meditation. It originated in Indian culture and is a combination of religious, ethical, and physical exercises (Yadav et al., 2022). According to the Gheranda Samhita, an

ancient yogic text, yoga is a holistic practice that encompasses physical postures, breath control, meditation, and spiritual development.

In the present study, yoga refers to the practice of asanas to bring about changes in cognitive functions such as concentration, attention, and working memory.

6.2 Meditation

Patanjali defines meditation (or yoga) as the "restriction (or stilling) of the fluctuations of the mind." Meditation, defined as a contemplative, self-regulatory practice that induces a state of relaxation or altered state of awareness, has many benefits attributed to its practice (Alexander et al., 2003; Bertone, 2020; Zeidan et al., 2010).

In the present study, meditation is the training of the mind to achieve a state of calmness and maintain focus and attention in the face of distractions.

6.3 Working Memory

Working memory refers to the mental capacity to temporarily and simultaneously store and process a limited amount of information to complete some ongoing cognitive tasks (Wen & Jackson, 2022).

In the present study, working memory refers to the ability to store, maintain, and process information related to a given task.

6.4 Mind Wandering:

Mind-wandering is defined as the inability to withhold responses to certain stimuli, indicating a lack of attention to the task, with response errors and reaction times used as markers of task performance and mind-wandering. Mind wandering is a spontaneous shifting of attention from a primary task that can happen in varying degrees. It is an unintentional and unrelated shift that occurs where the mind tends to regale in varied thoughts, which can disrupt the ongoing task performance (Smallwood, 2009).

In the present study, mind-wandering is defined as the inability to withhold responses to certain stimuli, indicating a lack of attention to the task.

6.5 Mathematical Abstraction Ability

Mathematical abstraction ability refers to the cognitive process of constructing new structures or concepts that can be used to solve mathematical problems. It involves several stages, including understanding the problem, planning problem-solving strategies, implementing the chosen strategy, and

re-examining the problem-solving process (Ningsih & Hidayati, 2022).

In the present study, mathematical abstraction ability is defined as the accuracy with which students solve problems related to abstraction in mathematics.

7.0 Delimitation of the Study

- The present study will be delimited to the secondary schools of Agra.
- The study will be conducted on class IX and X students of two secondary schools.

8.0 Objectives

Objective 1: To study the working memory of secondary school students.

Objective 2: To study the mind wandering of secondary school students.

Objective 3: To study the mathematical abstraction ability of secondary school students.

Objective 4: To study the effect of yoga on the working memory of secondary school students.

Objective 5: To study the effect of yoga on the mind wandering of secondary school students.

Objective 6: To study the effect of yoga on the mathematical abstraction ability of secondary school students.

Objective 7: To study the effect of meditation on the working memory of secondary school students.

Objective 8: To study the effect of meditation on the mind wandering of secondary school students.

Objective 9: To study the effect of meditation on the mathematical abstraction ability of secondary school students.

Objective 10: To study the comparative effect of yoga and meditation on the working memory of secondary school students.

Objective 11: To study the comparative effect of yoga and meditation on mind wandering of secondary school students.

Objective 12: To study the comparative effect of yoga and meditation on the mathematical abstraction ability of secondary school students.

Objective 13: To determine the indirect effect of yoga on the mathematical abstraction ability of students through working memory and mind wandering of secondary school students.

Objective 14: To determine the indirect effect of meditation on the mathematical abstraction ability of students through working memory and mind wandering of secondary school students.

Objective 15: To determine the direct effect of yoga on the mathematical abstraction ability of students after controlling for working memory and mind wandering of secondary school students.

Objective 16: To determine the direct effect of meditation on the mathematical abstraction ability of students after controlling for working memory and mind wandering of secondary school students.

9.0 Hypotheses

H_1: There will be a significant effect of yoga on the working memory of secondary school students.

H_2: There will be a significant effect of yoga on the mind wandering of secondary school students.

H_3: There will be a significant effect of yoga on the mathematical abstraction abilities of secondary school students.

H_4: There will be a significant effect of meditation on the working memory of secondary school students.

H_5: There will be a significant effect of meditation on the mind wandering of secondary school students.

H_6: There will be a significant effect of meditation on the mathematical abstraction ability of secondary school students.

H_7: There will be a significant difference between the effects of yoga and meditation on the working memory of secondary school students.

H_8: There will be a significant difference between the effects of yoga and meditation on the mind-wandering of secondary school students.

H_9: There will be a significant difference between the effects of yoga and meditation on the mathematical abstraction ability of secondary school students.

H_{10}: There will be a significant indirect effect of yoga on the mathematical abstraction ability of students through working memory and mind-wandering of secondary school students.

H_{11}: There will be a significant indirect effect of meditation on the mathematical abstraction ability of students through working memory and mind-wandering of secondary school students.

H_{12}: There will be a significant direct effect of yoga on the mathematical abstraction ability of students after controlling for working memory and mind-wandering of secondary school students.

H_{13}: There will be a significant direct effect of meditation on the mathematical abstraction ability of students after controlling for working memory and mind-wandering of secondary school students.

10.0 Sample Design

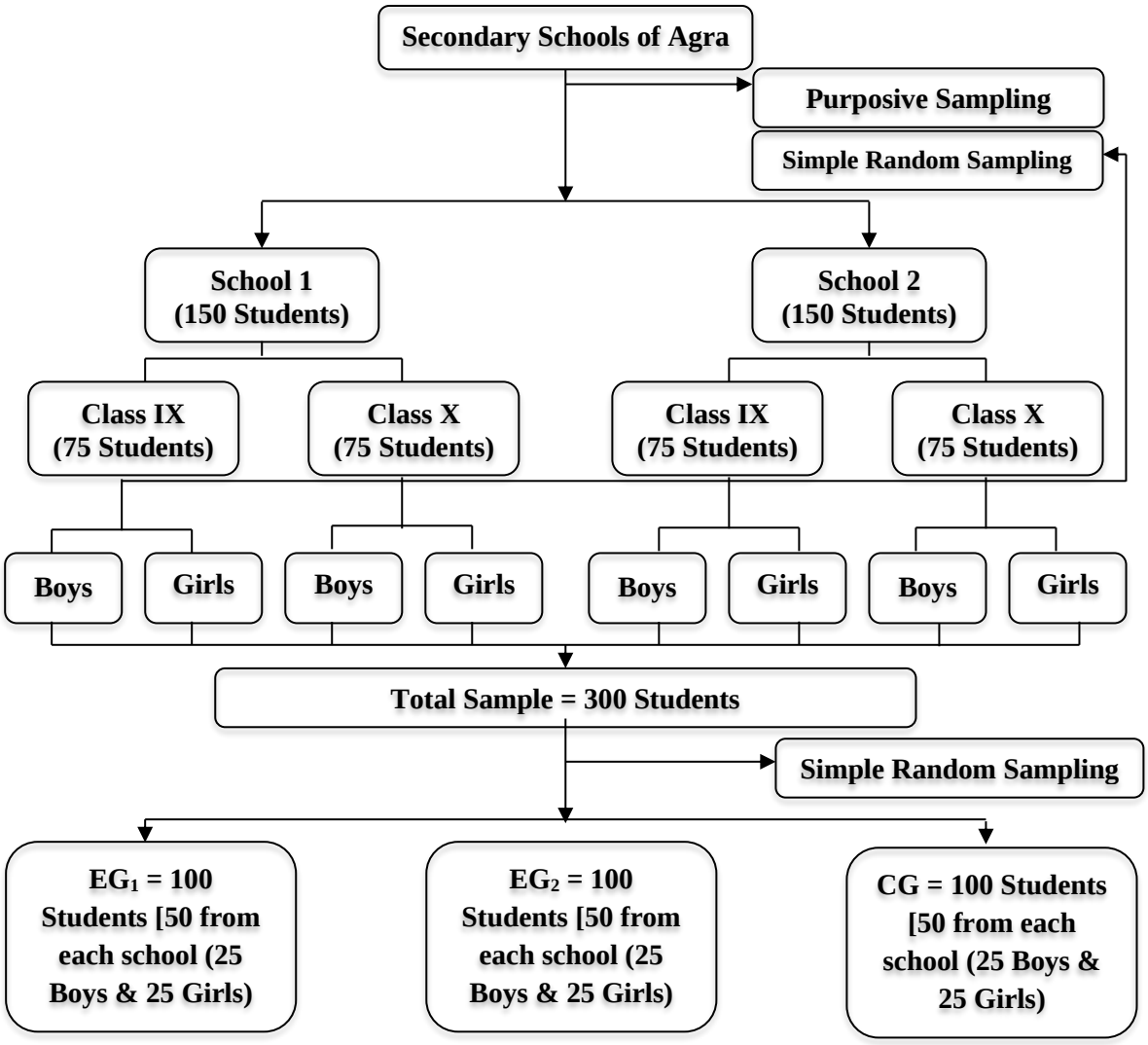
Secondary Schools of Agra
Purposive Sampling
Simple Random Sampling
School 1 (150 Students)
School 2 (150 Students)
Class IX (75 Students)
Class X (75 Students)
Class IX (75 Students)
Class X (75 Students)
Boys
Girls
Boys
Girls
Boys
Girls
Boys
Girls
Total Sample = 300 Students
Simple Random Sampling
EG1 = 100 Students [50 from each school (25 Boys & 25 Girls)
EG2 = 100 Students [50 from each school (25 Boys & 25 Girls)
CG = 100 Students [50 from each school (25 Boys & 25 Girls)

Fig. 1 *Sampling Procedure*

For data collection, two secondary schools will be chosen using purposive sampling. Students from classes IX and X at these schools will be classified based on gender. An equal number of boys ($n_1 = 75$) and girls ($n_2 = 75$) will be chosen from each school using simple random sampling, which will constitute the sample from each school, i.e., 150 students from each school. Thus, the total sample will be 300 students. An equal number of boys and girls from schools 1 and 2 will be allocated to three groups, namely Experimental Group 1 (EG_1), Experimental Group 2 (EG_2), and the Control Group (CG), using simple random sampling represented in Fig. 2

11.0 Methodology of the Study

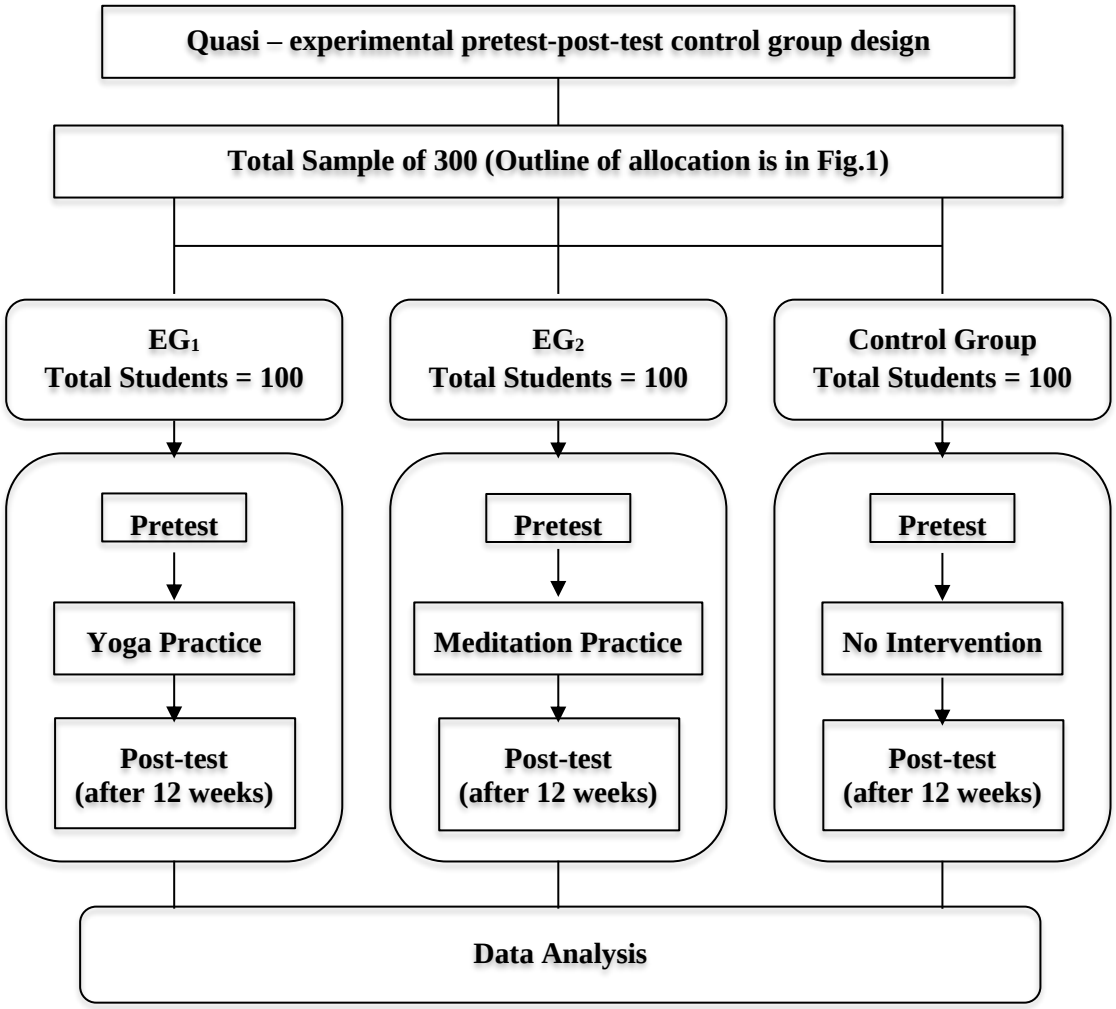

Fig. 2 *Research Design*

The research design for the present study is a quasi-experimental pretest-post-test control group design. The procedure for sample allocation is mentioned in Fig. 1 of the present study. The students of experimental group 1 will be exposed to yoga practice. The students of experimental group 2 will be exposed to meditation practice. The students in the control group will not undergo any intervention. Pre-test and post-tests on the working memory task, mind wandering task, and mathematical abstraction ability achievement test will be administered before and after the intervention. The scores of the tests will be used to investigate the effect of the interventions on the working memory, mind wandering, and mathematical abstraction abilities of secondary school students. This research design is visually represented in Fig. 2.

11.1 Intervention Programme

As per the literature reviewed for the present study, the yoga intervention ranged from 1 week (Sukumar, 2023; Upadhyay et al., 2019; Metri et al., 2018; Jeffries et al., 2022) to 24 weeks (Unick et al., 2023; Azami et al., 2019; Sharma, 2022), and the meditation intervention ranged from 3 weeks (Myint et al., 2011; Lim et al., 2015) to 15 weeks (Newsome et al., 2006; Schure et al., 2011). Some studies have conducted 16 weeks of yoga and meditation interventions targeting school teachers and educators (Harris et al., 2016; Mookiah et al., 2021). Longer interventions were aimed at expert meditators and experienced practitioners (Lewis et al., 2007; Yordanova et al., 2021; Dasanayaka et al., 2022). However, the school-based yoga and meditation interventions that have been reviewed had 3 to 12 weeks of intervention, for 15 - 20 minutes a day (Phan et al., 2022; Yadav et al., 2022; Yadav & Yadav, 2022; Bennett & Dorjee, 2016; Bakosh et al., 2015; Telles et al., 2013; Butzer et al., 2015; Bruner et al., 2017; Beauchemin et al., 2008). One of the reviewed studies conducted 16 weeks of yoga intervention (40 minutes a day, three times a week) that has been shown to improve emotional regulation among adolescents (Daly et al., 2015). 12-weeks of yoga and meditation intervention is beneficial for improving academic achievement due to its positive impact on various aspects of cognitive function and overall well-being (Natalia et al., 2024; Aalst et al., 2022; Saxena et al., 2020; Irarrazaval, 2019). Studies have shown that such interventions can significantly enhance spatial and verbal memory, improve reaction times (Naveen et al., 2022), and improve concentration, which are essential for academic success (Sahu et al., 2024). A 12-week yoga and meditation intervention for 35-40 minutes a day, two to three times a week, in high school students also showed protective effects by mitigating decreases in academic performance (Butzer et al., 2015). Another 12-week yoga and meditation intervention were found to significantly improve academic performance in school students, indicating that this duration is effective for enhancing academic achievement based on the study results (Jarvis et al., 2017; Karak et al., 2016). Therefore, the intervention for this study is proposed for 3 days a week (for each experimental group) for 12 weeks.

- **Intervention 1: Yoga Practice:**

During the intervention programme, participants in experimental group 1 will undergo a yoga session. 41 yoga asanas are shortlisted and classified into four categories, viz., standing, sitting, prone, and supine

postures. The proposed duration for which the yoga asanas will be practiced is 30 minutes a day, 3 days a week, for 12 weeks. After consulting with the expert yoga practitioner, the yoga asanas for the intervention programme and the duration for which each asana will be practiced will be finalised.

- **Intervention 2: Meditation Practice:**

Participants in experimental group 2 will be exposed to chakra meditation. Students will perform this meditation practice under the supervision of an experienced meditator. It will be practiced for 20 minutes, 3 days a week, for 12 weeks. The chakra meditation employed in this study involves the repetition of the syllables Ra Dha Sva Aa Mi at five chakras.

12.0 Tools

The following tools will be used for the collection of data.

12.1 n-back task

The n-back task is a cognitive task used to study working memory (WM) processes. It involves presenting a series of stimuli and requires participants to indicate whether the current stimulus matches the one presented n-step back in the sequence (Kimura & Matsuura, 2023).

12.1.1 Rationale of tool selection

Table 1 *Rationale of tool selection to measure working memory*

Title of the Study	Authors and Year	Name of the Tool	Rationale of Selection / Rejection	Status
Forward and backward span for verbal and visuospatial data: Standardisation and normative data from an Italian adult population	Monaco et al., 2012	Forward and backward span task	The forward and backward span tasks primarily assess specific components of working memory, such as the phonological loop and visuospatial sketchpad, but may not capture the full complexity of working memory processes.	Rejected
The ECAT Battery	Alderton et al., 2009	The ECAT Battery	It lacks comprehensive coverage of multiple working memory components	Rejected
N-back test of working memory	Amouzadeh et al., 2023	n-back	The n-back task challenges control over familiarity-based responding, making it a suitable measure of working memory.	Selected

			The task has been widely used in research and is considered a standard working memory measure.	

Table 1 illustrates the tools investigated to evaluate the working memory capacity of secondary school students for the current investigation. The n-back performance task is chosen for this purpose. The reasoning for opting for the n-back task and dismissing alternative instruments is discussed in Table 1.

12.2 Sustained Attention to Response Task (SART)

The Sustained Attention to Response Task (SART) is a commonly used task to measure mind wandering. It involves participants responding to a series of stimuli, typically go stimuli, while inhibiting responses to occasional no-go stimuli. The task is designed to capture shifts of attention from external tasks to internal thoughts, which is indicative of mind wandering (Liu et al., 2023).

12.2.1 Rationale of tool selection

Table 2 *Rationale of tool selection to measure mind wandering*

Title of the Study	Authors and Year	Name of the Tool	Rationale of Selection / Rejection	Status
The Metronome Counting Task for measuring meta-awareness	Thomas Anderson and Norman A. S. Farb, 2020	Metronome Counting Task (MCT)	The MCT relies on self-report measures, which may be subject to biases and inaccuracies in participants' reporting of their engagement and understanding of the instructions.	Rejected
Detecting Mind Wandering: An Objective Method via Simultaneous Control of Respiration and Fingertip Pressure	Zheng et al., 2019	Respiration–force coordinating task	The respiration-force coordinating task relies on the participants' ability to monitor their respiratory signals and produce correct fingertip force pulses, which may be subject to biases. Also, it lacks consistency in its results	Rejected
Are you mind-wandering, or is your mind on task? The effect of probe framing on mind-	Weinstein, 2017	Experience Sampling	Subjective self-report measures are entirely introspective and may not always accurately reflect participants' internal states.	Rejected

wandering reports				
Propensity to intentional and unintentional mind-wandering differs in arousal and executive vigilance tasks	Martínez-Pérez et al., 2021	Sustained Attention to Response Task (SART)	SART performance demonstrates evidence of measuring response strategy and trade-offs between speed and accuracy of responses, indicating the presence of mind wandering.	Selected

Table 2 discusses the instruments reviewed to evaluate the occurrence of mind wandering among students in secondary schools as of the current investigation. The Sustained Attention to Response Task (SART) is chosen for this purpose. The rationale behind opting for SART and dismissing alternative instruments is elaborated upon in Table 2.

12.3 Mathematical Abstraction Ability Test

A self-constructed achievement test will be used to assess the mathematical abstraction ability of secondary school students.

13.0 Statistical Techniques

The collected data will be subjected to the following statistical techniques:

13.1 Descriptive Statistics

Measures of Central Tendency, viz.

- Mean
- Standard Deviation

13.2 Inferential Statistics

13.2.1 t-test

t-test will be used to study the effect of yoga and meditation on mathematical abstraction ability to achieve objectives 4 - 9.

13.2.2 Mediation Analysis

Mediation analysis will be used to investigate the mediating role of working memory and mind wandering in the effect of yoga and meditation on mathematical abstraction ability. This will be used to attain objectives 13, 14, 15, and 16 of this study.

13.2.3 One-way ANOVA

In the present study, one-way ANOVA will be used to compare the treatment effects of yoga and meditation on working memory, mind wandering, and mathematical abstraction ability. It will be used to address objectives 10, 11, and 12.

References

Adams, J.W., & Holmes, J. (2006). Working Memory and Children's Mathematical Skills: Implications for mathematical development and mathematics curricula. *Educational Psychology, 26*(3), 339-366. https://doi.org/10.1080/01443410500341056

Aguilar, J. J. (2021). High School Students' Reasons for Disliking Mathematics: The Intersection between the teacher's role and the student's emotions, beliefs, and self-efficacy. *International Electronic Journal of Mathematics Education, 16*(3), em0658. https://doi.org/10.29333/iejme/11294

Ainley, J., Kos, J., & Nicholas, M. (2008). Participation in Science, Mathematics and Technology in Australian Education. *Australian Council for Educational Research*. https://research.acer.edu.au/acer_monographs/4

Alexander, C. E., Rainforth, M., Frank, P. R., Grant, J. D., Von Stade, C., & Walton, K. G. (2003). Walpole Study of the Transcendental Meditation Program in Maximum Security Prisoners III. *Journal of Offender Rehabilitation, 36*(1–4), 161–180. https://doi.org/10.1300/j076v36n01_08

Allen, K., Higgins, S., & Adams, J. B. (2019). The Relationship between Visuospatial Working Memory and Mathematical Performance in School-Aged Children: A Systematic Review. *Educational Psychology Review, 31*(3), 509–531. https://doi.org/10.1007/s10648-019-09470-8

Alloway, T. P., & Copello, E. (2013). Working Memory: The What, the Why, and the How, *The Australian Educational and Developmental Psychologist, 30*(2), 105-118. https://doi.org/10.1017/edp.2013.13

Andrews-Hanna, J. R., Smallwood, J., & Spreng, R. N. (2014). The default network and self-generated thought: component processes, dynamic control, and clinical relevance. *Annals of the New York Academy of Sciences, 1316*(1), 29–52. https://doi.org/10.1111/nyas.12360

Antrobus, J. S. (1968). Information Theory and Stimulus-Independent Thought. *British Journal of*

Psychology, 59(4), 423-430. https://doi.org/10.1111/j.2044-8295.1968.tb01157.x

Ash, R. B. (1998). A Primer of Abstract Algebra. Mathematical Association of America (MAA).

Baddeley, A., & Della Sala, S. (1996). Working memory and executive control. *Philosophical Transactions of the Royal Society B, 351*(1346), 1397–1404. https://doi.org/10.1098/rstb.1996.0123

Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation*, 47–89. https://doi.org/10.1016/s0079-7421(08)60452-1

Bae, H., & Kwon, K. (2021). Developing metacognitive skills through class activities: what makes students use metacognitive skills? *Educational Studies, 47*(4), 456–471. https://doi.org/10.1080/03055698.2019.1707068

Baird, B., Smallwood, J., Mrazek, M. D., Kam, J. W. Y., Franklin, M. S., and Schooler, J. W. (2012). Inspired by distraction: mind wandering facilitates creative incubation. *Psychological Science, 23*(10), 1117–1122. https://doi.org/10.1177/0956797612446024

Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. *Consciousness and Cognition, 20*(4), 1604–1611. https://doi.org/10.1016/j.concog.2011.08.007

Bakosh, L. S., Snow, R. M., Tobias, J. M., Houlihan, J. L., & Barbosa-Leiker, C. (2015). Maximizing Mindful Learning: Mindful Awareness intervention improves elementary school students' quarterly grades. *Mindfulness*, *7*(1), 59–67. https://doi.org/10.1007/s12671-015-0387-6

Basavaraddi, I. V. (2015, April 23). *Yoga: Its origin, history and development*. Ministry External Affairs. https://www.mea.gov.in/search-result.htm?25096/Yoga:_su_origen,_historia_y_desarrollo

Beauchemin, J., Hutchins, T. L., & Patterson, F. (2008). Mindfulness meditation may lessen anxiety, promote social skills, and improve academic performance among adolescents with learning disabilities. *Complementary Health Practice Review*, *13*(1), 34–45. https://doi.org/10.1177/1533210107311624

Bennett, K., & Dorjee, D. (2015). The Impact of a Mindfulness-Based Stress Reduction Course (MBSR) on Well-Being and Academic Attainment of Sixth-form students. *Mindfulness, 7*(1), 105–114.

https://doi.org/10.1007/s12671-015-0430-7

Benu, P. (2022, January 26). *Data focus: Almost 90 percent of India's VIII graders are not proficient in mathematics, UNESCO report*. BusinessLine. https://www.thehindubusinessline.com/data-stories/data-focus/data-focus-almost-90-per-cent-of-indias-viii-graders-are-not-proficient-in-mathematics-unesco-report/article64940386.ece

Bertone, H. J. (2020, November 5). *Which type of meditation is right for me?* Healthline. https://www.healthline.com/health/mental-health/types-of-meditation#takeaway

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development, 81*(6), 1641–1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Bogomolny, A. (2018). *What is abstraction?*. Interactive Mathematics Miscellany and Puzzles. https://www.cut-the-knot.org/WhatIs/WhatIsAbstract.shtml#Gene

Brandmeyer, T., & Delorme, A. (2020). Meditation and the wandering mind: a theoretical framework of underlying neurocognitive mechanisms. *Perspectives on Psychological Science, 16(*1), 39–66. https://doi.org/10.1177%2F1745691620917340

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences of the United States of America, 104*(27), 11483–11488. https://doi.org/10.1073/pnas.0606552104

Brewer, J. A., Worhunsky, P. D., Gray, J. R., Tang, Y., Weber, J., & Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences of the United States of America, 108*(50), 20254–20259. https://doi.org/10.1073/pnas.1112029108

Bruner, D., Abramovitch, A., & Etherton, J. (2017). A yoga program for cognitive enhancement. *PLoS ONE, 12*(8). https://doi.org/10.1371/journal.pone.0182366

Butzer, B., Van Over, M., Taylor, J. J. N., & Khalsa, S. B. S. (2015). Yoga may mitigate decreases in high school grades. *Evidence-based Complementary and Alternative Medicine, 2015*, 1–8. https://doi.org/10.1155/2015/259814

Cakır, R., & Ergül, C. (2022). Investigation of Working Memory Performances of Children with Low

Early Mathematics Achievement. *Eğitim Ve Bilim, 47*(209). https://doi.org/10.15390/eb.2022.10389

Carriere, J. S. A., Seli, P., & Smilek, D. (2013). Wandering in both mind and body: Individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology, 67*(1), 19–31. https://doi.org/10.1037/a0031438

Carter, O., Presti, D. E., Callistemon, C., Ungerer, Y., Liu, G., & Pettigrew, J. D. (2005). Meditation alters perceptual rivalry in Tibetan Buddhist monks. *Current Biology, 15*(11), R412–R413. https://doi.org/10.1016/j.cub.2005.05.043

Caruso, M., & D'Mello, S. (2023). Do associations between mind wandering and learning from complex texts vary by assessment depth and time? *LAK23: 13th International Learning Analytics and Knowledge Conference.* https://doi.org/10.1145/3576050.3576084

Cekanauskaite, A., Skurvydas, A., Žlibinaitė, L., Mickevičienė, D., Kilikevičienė, S., & Solianik, R. (2020). A 10-week yoga practice has no effect on cognition, but improves balance and motor learning by attenuating brain-derived neurotrophic factor levels in older adults. *Experimental Gerontology, 138*, 110998. https://doi.org/10.1016/j.exger.2020.110998

Chand, S., Chaudhary, K., Prasad, A., & Chand, V. (2021). Perceived causes of students' poor performance in mathematics: a case study at BA and Tavua Secondary Schools. *Frontiers in Applied Mathematics and Statistics, 7*. https://doi.org/10.3389/fams.2021.614408

Chatzi, A., & Doody, O. (2023). The One-way anova test explained. *Nurse Researcher, 31*(3), 8–14. https://doi.org/10.7748/nr.2023.e1885

Chinnappan, M., Dinham, S., Herrington, A. J., & Scott, D. (2008). Year 12 students' and higher mathematics: emerging issues. *International Educational Research Conference* (p. 10). https://doi.org/https://ro.uow.edu.au/edupapers/684/

Chiorri, C., & Vannucci, M. (2019). Replicability of the psychometric properties of Trait-Levels measures of spontaneous and deliberate mind wandering. *European Journal of Psychological Assessment, 35*(4), 459–468. https://doi.org/10.1027/1015-5759/a000422

Christoff, K., Irving, Z. C., Fox, K. C., Spreng, R. N., & R., J. (2016). Mind-wandering as spontaneous thought: A dynamic framework. *Nature Reviews Neuroscience, 17*(11), 718-731.

https://doi.org/10.1038/nrn.2016.113

Cohen, L., Dehaene, S., Chochon, F., Lehéricy, S., & Naccache, L. (2000). Language and calculation within the parietal lobe: a combined cognitive, anatomical and fMRI study. *Neuropsychologia*, *38*(10), 1426–1440. https://doi.org/10.1016/s0028-3932(00)00038-5

Conway, M. A. (2001). Sensory–perceptual episodic memory and its context: autobiographical memory. *Philosophical Transactions - Royal Society. Biological Sciences*, *356*(1413), 1375–1384. https://doi.org/10.1098/rstb.2001.0940)

Cowan, N. (2013). Working memory underpins cognitive development, learning, and education. *Educational Psychology Review*, *26*(2), 197–223. https://doi.org/10.1007/s10648-013-9246-y

Cowan, N., & Alloway, T. (2008). Development of working memory in childhood. In *The Development of Memory in Infancy and Childhood* (2nd ed., pp. 303–342). Psychology Press. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203934654-16/development-working-memory-childhood-nelson-cowan-tracy-alloway

Dai, C., Nabors, L., Vidourek, R. A., King, K. A., & Chen, C. (2015). Evaluation of an afterschool yoga program for children. *International Journal of Yoga*, *8*(2), 160. https://doi.org/10.4103/0973-6131.158488

Daly, L. A., Haden, S. C., Hagins, M., Papouchis, N., & Ramirez, P. M. (2015). Yoga and emotion regulation in high school students: a randomized controlled trial. *Evidence-based Complementary and Alternative Medicine*, *2015*, 1–8. https://doi.org/10.1155/2015/794928

Dasanayaka, N. N., Sirisena, N. D., & Samaranayake, N. (2022). Impact of Meditation-Based Lifestyle Practices on mindfulness, wellbeing, and plasma Telomerase Levels: A Case-Control Study. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.846085

Davidson, R. J., & Lutz, A. (2008). Buddha's Brain: Neuroplasticity and Meditation [In the Spotlight]. IEEE Signal Processing Magazine, 25(1), 176–174. https://doi.org/10.1109/msp.2008.4431873

Deepeshwar, S., Vinchurkar, S. A., Visweswaraiah, N. K., & Nagendra, H. R. (2015). Hemodynamic responses on prefrontal cortex related to meditation and attentional task. *Frontiers in Systems Neuroscience*, *8*, 125182. https://doi.org/10.3389/fnsys.2014.00252

Delavari, H., Talebi, M. E., & Delavari, H. (2023). Transforming education: A review of the benefits of

integrating mindfulness and meditation techniques in schools. *English Education Journal, 14*(2), 604–614. https://doi.org/10.24815/eej.v14i2.31992

Deng, X., Yang, M., & An, S. (2021). Differences in frontal EEG asymmetry during emotion regulation between high and low mindfulness adolescents. *Biological Psychology, 158*, 107990. https://doi.org/10.1016/j.biopsycho.2020.107990

Devlin, K. J. (2000). *The Math Gene: How Mathematical Thinking Evolved And Why Numbers Are Like Gossip.* https://archive.org/details/B-001-001-285/page/n7/mode/2up

Diamond, A., & Lee, K. (2011). Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old. *Science*, *333*(6045), 959–964. https://doi.org/1204529

Dinius, C. J., Pocknell, C. E., Caffrey, M. P., & Roche, R. A. (2023). Cognitive interventions for memory and psychological well-being in aging and dementias. *Frontiers in Psychology, 14*, 1070012. https://doi.org/10.3389/fpsyg.2023.1070012

Dowker, A., & Sheridan, H. (2022). Relationships Between Mathematics Performance and Attitude to Mathematics: Influences of Gender, Test Anxiety, and Working Memory. *Frontiers in Psychology, 13*, 814992. https://doi.org/10.3389/fpsyg.2022.814992

Dreyfus, T. (2002). Advanced mathematical thinking processes. In D. Tall (Ed.), *Advanced mathematical thinking* (pp. 25-41). Springer, Dordrecht. https://doi.org/10.1007/0-306-47203-1_2

Eastman-Mueller, H., Wilson, T., Jung, A., Kimura, A., & Tarrant, J. (2013). IREsT Yoga-Nidra on the college Campus: Changes in stress, depression, worry, and mindfulness. *International Journal of Yoga Therapy*, *23*(2), 15–24. https://doi.org/10.17761/ijyt.23.2.r8735770101m8277

Ei, W. Y., & Oo, C. Z. (2023). Effects of a Working Memory Training Program on Secondary School Students' Mathematics Achievement. *Mathematics Teaching Research Journal*, *15*(5). https://www.researchgate.net/publication/376683604_Effects_of_a_Working_Memory_Training_Program_on_Secondary_School_Students'_Mathematics_Achievement#fullTextFileContent

Engelbrecht, J. (2010). Adding structure to the transition process to advanced mathematical activity. *International Journal of Mathematical Education in Science and Technology*, *41*(2), 143–154.

https://doi.org/10.1080/00207390903391890

Farley, J., Risko, E., & Kingstone, A. (2013). Everyday attention and lecture retention: The effects of time, fidgeting, and mind wandering. *Frontiers in Psychology, 4*, 57742. https://doi.org/10.3389/fpsyg.2013.00619

Forgasz, H. (2006). Teachers, equity, and computers for secondary mathematics learning. *Journal of Mathematics Teacher Education, 9*(5), 437–469. https://doi.org/10.1007/s10857-006-9014-8

Fuchs, L. S., Gilbert, J. K., Powell, S. R., Cirino, P. T., Fuchs, D., Hamlett, C. L., Seethaler, P. M., & Tolar, T. D. (2016). The role of cognitive processes, foundational math skill, and calculation accuracy and fluency in word-problem solving versus prealgebraic knowledge. *Developmental Psychology, 52*(12), 2085–2098. https://doi.org/10.1037/dev0000227

Fumoto, M., Oshima, T., Kamiya, K., Kikuchi, H., Seki, Y., Nakatani, Y., Yu, X., Sekiyama, T., Sato-Suzuki, I., & Arita, H. (2010). Ventral prefrontal cortex and serotonergic system activation during pedaling exercise induces negative mood improvement and increased alpha band in EEG. *Behavioural Brain Research, 213*(1), 1–9. https://doi.org/10.1016/j.bbr.2010.04.017

Gathercole, S., & Alloway, T. P. (2004). Working memory and classroom learning. *The Psychologist, 15*(5).https://www.researchgate.net/publication/254392644_Working_memory_and_classroom_learning

Giambra, L. M. (1989). Task-unrelated thought frequency as a function of age: A laboratory study. *Psychology and Aging, 4*(2), 136–143. https://doi.org/10.1037/0882-7974.4.2.136

Gilead, M., Liberman, N., & Maril, A. (2013). From mind to matter: neural correlates of abstract and concrete mindsets. *Social Cognitive and Affective Neuroscience, 9*(5), 638–645. https://doi.org/10.1093/scan/nst031

Gilmore, C. (2023). Understanding the complexities of mathematical cognition: A multi-level framework. *Quarterly Journal of Experimental Psychology, 76*(9), 1953–1972. https://doi.org/10.1177/17470218231175325

Gorini, C., & Runkle, S. (2023, April). *Modern Mathematics and Its Fulfillment in Maharishi Vedic Mathematics, the Mathematics of Consciousness.* ResearchGate. https://www.researchgate.net/publication/370210789_Modern_Mathematics_and_Its_Fulfillm

ent_in_Maharishi_Vedic_Mathematics_the_Mathematics_of_Consciousness#fullTextFileContent

Gothe, N. P., Kramer, A. F., & McAuley, E. (2014). The effects of an 8-Week hatha yoga intervention on executive function in older adults. *The Journals of Gerontology: Series A, 69*(9), 1109–1116. https://doi.org/10.1093/gerona/glu095

Gothe, N. P., & McAuley, E. (2015). Yoga and Cognition: A Meta-Analysis of Chronic and Acute Effects. *Psychosomatic Medicine 77*(7), 784-797. https://doi.org/10.1097/PSY.0000000000000218

Greicius et al., 2003; (https://pubmed.ncbi.nlm.nih.gov/12506194/) Greicius, M. D., Krasnow, B., Reiss, A. L., & Menon, V. (2002). Functional connectivity in the resting brain: A network analysis of the default mode hypothesis. *Proceedings of the National Academy of Sciences of the United States of America, 100*(1), 253–258. https://doi.org/10.1073/pnas.0135058100

Hariprasad, V., Pt, S., Koparde, V., Varambally, S., Thirthalli, J., Varghese, M., Basavaraddi, I. V., & Gangadhar, B. N. (2013). Effects of yoga intervention on sleep and quality-of-life in elderly: A randomised controlled trial. *Indian Journal of Psychiatry, 55*(7), 364. https://doi.org/10.4103/0019-5545.116310

Harris, A. R., Jennings, P. A., Katz, D. A., Abenavoli, R. M., & Greenberg, M. T. (2015). Promoting Stress Management and Wellbeing in Educators: Feasibility and Efficacy of a School-Based Yoga and Mindfulness Intervention. *Mindfulness*, *7*(1), 143–154. https://doi.org/10.1007/s12671-015-0451-2

Heusel, L., Glaesser, J., Kilian, P., Merk, S., & Kelava, A. (2023). Comparing dropout intentions of math students on trainee teacher courses versus bachelor of science courses using intensive longitudinal data. *Frontiers in Education, 8*, 1205949. https://doi.org/10.3389/feduc.2023.1205949

Ho, K. F. (2015). *Year 11 Advanced Mathematics: Hearing from Students who Buck the Trend*. Researchgate, 248–255. https://doi.org/https://www.researchgate.net/publication/268202815_Year_11_Advanced_Mathematics_Hearing_from_Students_who_Buck_the_Trend

Hölzel, B. K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S. M., Gard, T., & Lazar, S. W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. P*sychiatry Research: Neuroimaging, 191*(1), 36–43. https://doi.org/10.1016/j.pscychresns.2010.08.006

Hoy, S., Östh, J., Pascoe, M., Kandola, A., & Hallgren, M. (2021). Effects of yoga-based interventions on cognitive function in healthy older adults: A systematic review of randomized controlled trials. *Complementary Therapies in Medicine, 58*, 102690. https://doi.org/10.1016/j.ctim.2021.102690

Hoyles, C., Newman, K., & Noss, R. (2001). Changing patterns of transition from school to university mathematics. *International Journal of Mathematical Education in Science and Technology, 32*(6), 829–845. https://doi.org/10.1080/00207390110067635

Jarvis, M. (2017). Meditation and yoga associated with changes in brain. *Science*, *358*(6362), 461. https://doi.org/10.1126/science.358.6362.461

Jeffries, E. (2022). *A randomized controlled trial of a hatha yoga intervention for smokers*. https://doi.org/10.31390/gradschool_dissertations.4692

Juniati, D., & Budayasa, I. K. (2020). Working Memory Capacity and Mathematics Anxiety of Mathematics Undergraduate Students and Its Effect on Mathematics Achievement. *Journal for the Education of Gifted Young Scientists, 8*(1), 271-290. https://doi.org/10.17478/jegys.653518

Kam, J. W. Y., & Handy, T. C. (2013). The neurocognitive consequences of the wandering mind: a mechanistic account of sensory-motor decoupling. *Frontiers in Psychology, 4*. https://doi.org/10.3389/fpsyg.2013.00725

Kane, M. J., & McVay, J. C. (2012). What Mind Wandering Reveals About Executive-Control Abilities and Failures. *Current Directions in Psychological Science, 21*(5), 348-354. https://doi.org/10.1177/0963721412454875

Karak, K., Ghoshal, A., & Mahammad, S. R. (2016). Effect of yogasana on academic performance of school going students. *International Journal of Physical Education, Sports and Health*, *3*(4), 194–197. https://www.kheljournal.com/archives/2016/vol3issue4/PartD/3-4-6-654.pdf

Kauts, A., & Sharma, N. (2009). Effect of yoga on academic performance in relation to stress. *International Journal of Yoga, 2*(1), 39-43. https://doi.org/10.4103/0973-6131.53860

Killingsworth, M. R., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science, 330*(6006), 932. https://doi.org/10.1126/science.1192439

Kozasa, E. H., Sato, J. R., Lacerda, S. N. B., Barreiros, M. Â. M., Radvany, J., Russell, T., Sanches, L. G., Mello, L. E., & Amaro, E. (2012). Meditation training increases brain efficiency in an attention task. *NeuroImage, 59*(1), 745–749. https://doi.org/10.1016/j.neuroimage.2011.06.088

Kushwaha, S. R. (2016). Effect of yoga on mathematics achievement [Thesis]. Tribhuvan University, Kirtipur, Kathmandu.

Lazar, S. W., Kerr, C. E., Wasserman, R. H., Gray, J. R., Greve, D. N., Treadway, M. T., McGarvey, M., Quinn, B. T., Dusek, J. A., Benson, H., Rauch, S. L., Moore, C. I., & Fischl, B. (2005). Meditation experience is associated with increased cortical thickness. *Neuroreport, 16*(17), 1893. https://doi.org/10.1097/01.wnr.0000186598.66243.19

Lemay, V., Hoolahan, J., & Buchanan, A. (2019). Impact of a yoga and meditation intervention on students' stress and anxiety levels. *American Journal of Pharmaceutical Education, 83*(5), 7001. https://doi.org/10.5688/ajpe7001

Lim, S., & Cheong, K. (2015). Regular yoga practice improves antioxidant status, immune function, and stress hormone releases in young healthy people: a randomized, Double-Blind, controlled pilot study. *the Journal of Alternative and Complementary Medicine/Journal of Alternative and Complementary Medicine*, *21*(9), 530–538. https://doi.org/10.1089/acm.2014.0044

Lindquist, S. I., & McLean, J. P. (2011). Daydreaming and its correlates in an educational environment. *Learning and Individual Differences, 21*(2), 158-167. https://doi.org/10.1016/j.lindif.2010.12.006

Liu, Y., Liu, Y., & Wang, C. (2022). The effect of mindfulness meditation on academic performance of students. *Advances in Social Science, Education and Humanities Research.* https://doi.org/10.2991/assehr.k.220110.012

Luders, E., Toga, A. W., Lepore, N., & Gaser, C. (2009). The underlying anatomical correlates of long-term meditation: Larger hippocampal and frontal volumes of gray matter. *NeuroImage, 45*(3), 672–678. https://doi.org/10.1016/j.neuroimage.2008.12.061

Lutz, A., Greischar, L. L., Rawlings, N. B., Ricard, M., & Davidson, R. J. (2004). Long-term meditators

self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(46), 16369–16373. https://doi.org/10.1073/pnas.0407401101

Lutz, A., Dunne, J., & Davidson, R. J. (2007). Meditation and the neuroscience of consciousness: an introduction. In *Cambridge University Press eBooks*. https://doi.org/10.1017/cbo9780511816789.020

Lutz, A., Slagter, H. A., Rawlings, N. B., Francis, A. D., Greischar, L. L., & Davidson, R. J. (2009). Mental training enhances attentional stability: neural and behavioral evidence. *The Journal of Neuroscience*, *29*(42), 13418–13427. https://doi.org/10.1523/jneurosci.1614-09.2009

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology*, *58*(1), 593–614. https://doi.org/10.1146/annurev.psych.58.110405.085542

Mason et al., 2007; https://www.science.org/doi/10.1126/science.1131295 Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. N. (2007). Wandering Minds: the default network and Stimulus-Independent thought. Science, 315(5810), 393–395. https://doi.org/10.1126/science.1131295

Matko, K., & Sedlmeier, P. (2019). What is meditation? Proposing an empirically derived classification system. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02276

McCurdy, B. H., Bradley, T., Matlow, R., Rettger, J. P., Espil, F. M., Weems, C. F., & Carrión, V. G. (2023). Program Evaluation of a School-Based Mental Health and Wellness Curriculum Featuring Yoga and Mindfulness. *Health And Wellness*. https://doi.org/10.31234/osf.io/q2a5u

Mckiernan, K. A., Kaufman, J. N., Kucera-Thompson, J., & Binder, J. R. (2003). A parametric manipulation of factors affecting task-induced deactivation in functional neuroimaging. *Journal of Cognitive Neuroscience*, *15*(3), 394–408. https://doi.org/10.1162/089892903321593117

McKiernan, K. A., D'Angelo, B. R., Kaufman, J. N., & Binder, J. R. (2006). Interrupting the "stream of consciousness": An fMRI investigation. NeuroImage, 29(4), 1185–1191. https://doi.org/10.1016/j.neuroimage.2005.09.030

McVay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind wandering across controlled and

ecological contexts. *Psychonomic Bulletin & Review, 16*(5), 857–863. https://doi.org/10.3758/pbr.16.5.857

Mehling, W., Price, C., Daubenmier, J., Acree, M., Bartmess, E., & Stewart, A. L. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *PLOS ONE, 7*(11), e48230. https://doi.org/10.1371/journal.pone.0048230

Mehling, W. E., Acree, M., Stewart, A., Silas, J., & Jones, A. (2018). The Multidimensional Assessment of Interoceptive Awareness, Version 2 (MAIA-2). *PLoS ONE, 13*(12). https://doi.org/10.1371/journal.pone.0208034

Metri, K. G., Pradhan, B., Singh, A., & Nagendra, H. R. (2018). Effect of 1-week yoga-based residential program on cardiovascular variables of hypertensive patients: A Comparative Study. *International Journal of Yoga/International Journal of Yoga*, *11*(2), 170. https://doi.org/10.4103/ijoy.ijoy_77_16

Miksza, P., Shaw, J. T., Richerme, L. K., Hash, P. M., Hodges, D. A., & Parker, E. C. (2023). Correlational statistics. In *Oxford University Press eBooks* (pp. 347–370). https://doi.org/10.1093/oso/9780197639757.003.0017

Mitchell, J. P., Cloutier, J., Banaji, M. R., & Macrae, C. N. (2006). Medial prefrontal dissociations during processing of trait diagnostic and nondiagnostic person information. *Social Cognitive and Affective Neuroscience*, *1*(1), 49–55. https://doi.org/10.1093/scan/nsl007

Mitchelmore, M., & White, P. (2007). Abstraction in mathematics learning. *Mathematics Education Research Journal*, *19*(2), 1–9. https://doi.org/10.1007/bf03217452

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological Science*, *24*(5), 776–781. https://doi.org/10.1177/0956797612459659

Myint, K., & Tin Tin Su. Lam, SK (2011). The effect of short term practice of mindfulness meditation in alleviating stress in university students. *Biomedical Research 2011;*, *22*(2), 165–171. https://www.researchgate.net/publication/236202490_The_effect_of_short_term_practice_of_mindfulness_meditation_in_alleviating_stress_in_University_students

Natalia, K., Utomo, B., & Suherman, H. (2024). Mindfulness Practices to Improve Achievement.

JETISH: Journal of Education Technology Information Social Sciences and Health, 3(1), 542-545.

Naveen, N. A., Sayeli, N. V. K., & Pokala, N. U. (2022). Effectiveness of 12-week Om chanting on reaction time and spatial and verbal memory. *Asian Journal of Medical Sciences, 13*(10), 233–236. https://doi.org/10.3126/ajms.v13i10.45067

Newsome, S., Christopher, J. C., Dahlen, P., & Christopher, S. (2006). Teaching Counselors Self-Care through Mindfulness Practices. *Teachers College Record*, *108*(9), 1881–1900. https://doi.org/10.1177/016146810610800912

Nicholas, J., Poladian, L., Mack, J., and Wilson, R. (2015). Mathematics preparation for university: entry, pathways and impact on performance in first year science and mathematics subjects. *International Journal of Innovation in Science and Mathematics Education, 23*(1), 37-51. https://openjournals.library.sydney.edu.au/CAL/article/view/8488

Nidich, S., Mjasiri, S., Nidich, R., Rainforth, M., Grant, J., Valosek, L., Chang, W., & Zigler,

R. L. (2011). Academic achievement and transcendental meditation: a study with at-risk urban middle school students. *Education, 131*(3), 556+. https://link.gale.com/apps/doc/A253740215/AONE?u=anon~f503f9f7&sid=googleScholar&xid=759853cb

Nur, I. R. D., Herman, T., & Ningsih, S. (2018). Working Memory in Students with Mathematical Difficulties. *IOP Conference Series: Materials Science and Engineering, 335,* 012114. https://doi.org/10.1088/1757-899x/335/1/012114

Nurjannah, S., & Kusnandi. (2021). Literature study: the role of abstraction ability to strengthen students early knowledge in mathematics learning. *Journal of Physics: Conference Series*, *1806*(1), 012064. https://doi.org/10.1088/1742-6596/1806/1/012064

Oken, B. S., Zajdel, D., Kishiyama, S., Flegal, K., Dehen, C., Haas, M., Kraemer, D. F., Lawrence, J., & Leyva, J. (2006). Randomized, controlled, six-month trial of yoga in healthy seniors: effects on cognition and quality of life. *Alternative Therapies in Health and Medicine, 12*(1), 40. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1457100/

Ortiz, Z. (2023). Exploring the Theory of Mathematical Modelling: Unlocking the Power of Abstraction.

Journal of Physical Mathematics, 14(4), 434. https://www.hilarispublisher.com/open-access/exploring-the-theory-of-mathematical-modelling-unlocking-the-power-of-abstraction.pdf

Pachai, A. A., Acai, A., LoGiudice, A. B., & Kim, J. A. (2016). The mind that wanders: Challenges and potential benefits of mind wandering in education. *Scholarship of Teaching and Learning in Psychology, 2*(2), 134–146. https://doi.org/10.1037/stl0000060

Pagnoni, G., & Cekić, M. (2007). Age effects on gray matter volume and attentional performance in Zen meditation. *Neurobiology of Aging, 28*(10), 1623–1627. https://doi.org/10.1016/j.neurobiolaging.2007.06.008

Pandey, M. P., & Dagar, C. (2022). Cognitive flexibility through the path of yoga. *GLIMS Journal of Management Review and Transformation.* https://doi.org/10.1177/jmrt.22.1069776

Pandya, S. P. (2018). Yoga, emotional awareness and happiness in children: A multi-city study of the Chinmaya Bala Vihar programme. *Child & Youth Care Forum, 47*(6), 897–917. https://doi.org/10.1007/s10566-018-9468-8

Pathath, A. W. (2017). Meditation: techniques and benefits. *International Journal of Current Research in Medical Sciences, 3*(6), 162–168. https://doi.org/10.22192/ijcrms.2017.03.06.021

Peng, P., Barnes, M. A., Wang, C. C., Wang, W., Li, S., Swanson, H. L., Dardick, W., & Tao, S. (2018). A meta-analysis on the relation between reading and working memory. *Psychological Bulletin, 144*(1), 48–76. https://doi.org/10.1037/bul0000124

Phadnis, S., & John, S. (2019, June 25). Mathematics is on decline in India. reason: Excessive focus on engineering. *The Economic Times.* https://economictimes.indiatimes.com/jobs/mathematics-is-on-decline-in-india-reason-excessive-focus-on-engineering/articleshow/69938324.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)

Phan, M. L., Renshaw, T. L., Caramanico, J., Greeson, J. M., MacKenzie, E., Atkinson-Diaz, Z., Doppelt, N., Tai, H., Mandell, D. S., & Nuske, H. J. (2022). Mindfulness-Based School Interventions: a Systematic Review of Outcome Evidence Quality by Study Design. *Mindfulness, 13*(7), 1591–1613. https://doi.org/10.1007/s12671-022-01885-9

Qavam, S., Azami, M., Ahmadi, M. H., & YektaKooshali, M. (2019). Effect of yoga on lipid profile and c-reactive protein in women. *International Journal of Preventive Medicine/International Journal of Preventive Medicine.*, *10*(1), 81. https://doi.org/10.4103/ijpvm.ijpvm_487_17

Quiroga, R. Q., Reddy, L., Kreiman, G., Koch, C., & Fried, I. (2005). Invariant visual representation by single neurons in the human brain. *Nature*, *435*(7045), 1102–1107. https://doi.org/10.1038/nature03687

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001b). A default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(2), 676–682. https://doi.org/10.1073/pnas.98.2.676

Randall, T. C., Sauvaget, C., Muwonge, R., Trimble, E. L., & Jerónimo, J. (2019). Worthy of further consideration: An updated meta-analysis to address the feasibility, acceptability, safety and efficacy of thermal ablation in the treatment of cervical cancer precursor lesions. *Preventive Medicine*, *118*, 81–91. https://doi.org/10.1016/j.ypmed.2018.10.006

Ratey, J. J., & Hagerman, E. (2008). *Spark: The Revolutionary New Science of Exercise and the Brain.* Little Brown and Co.

Risko, E. F., Anderson, N., Sarwal, A., Engelhardt, M., & Kingstone, A. (2012). Everyday Attention: Variation in Mind Wandering and Memory in a Lecture. *Applied Cognitive Psychology*, *26*(2), 234-242. https://doi.org/10.1002/acp.1814

Robison, M. K., Gath, K. I., & Unsworth, N. (2017). The neurotic wandering mind: An individual differences investigation of neuroticism, mind-wandering, and executive control. *Quarterly Journal of Experimental Psychology*. https://doi.org/10.1080/17470218.2016.1145706

Sahu, A., Chauhan, S. S., & Popatrao, J. B. (2024). Enhancing athletic performance and academic success: The role of yoga in Bhopal\'s volleyball players. *International Journal for Research in Applied Science and Engineering Technology*, *12*(5), 2566–2570. https://doi.org/10.22214/ijraset.2024.62134

Saidi, N., & Rao, G. S. (2023). Application of discriminant analysis to predict students' performances in mathematics in advanced secondary schools. *European Journal of Statistics*, *3*, 8. https://doi.org/10.28924/ada/stat.3.8

Sakai, J. (2012, March 15). *A wandering mind reveals mental processes and priorities*. University of Wisconsin – Madison: News. https://news.wisc.edu/a-wandering-mind-reveals-mental-processes-and-priorities/

Saxena, K., Verrico, C. D., Saxena, J., Kurian, S., Alexander, S., Kahlon, R. S., Arvind, R. P., Goldberg, A., DeVito, N., Baig, M., Grieb, A., Bakhshaie, J., Simonetti, A., Storch, E. A., Williams, L., & Gillan, L. (2020). An evaluation of yoga and meditation to improve attention, hyperactivity, and stress in high-school students. *The Journal of Alternative and Complementary Medicine*, *26*(8), 701–707. https://doi.org/10.1089/acm.2020.0126

Schure, M. B., Christopher, J., & Christopher, S. (2008). Mind–Body Medicine and the Art of Self-Care: Teaching mindfulness to counseling students through yoga, meditation, and Qigong. *Journal of Counseling and Development*, *86*(1), 47–56. https://doi.org/10.1002/j.1556-6678.2008.tb00625.x

Seli, P., Wammes, J. D., Risko, E. F., & Smilek, D. (2015). On the relation between motivation and retention in educational contexts: The role of intentional and unintentional mind wandering. *Psychonomic Bulletin & Review, 23*(4), 1280–1287. https://doi.org/10.3758/s13423-015-0979-0

Sharma, H. (2015). Meditation: process and effects. *AYU (An International Quarterly Journal of Research in Ayurveda), 36*(3), 233. https://doi.org/10.4103/0974-8520.182756

Sharma, N. (2022). Yoga intervention in health and lifestyle modification. *Southeast Asian Journal of Health Professionals*, *5*(1), 1–3. https://doi.org/10.18231/j.sajhp.2022.001

Sidhu, J. K. (2022, February 3). *Meditation in School Education: a profound practice* – Ideas that matter. https://www.ideasthatmatter.in/2022/02/03/meditation-in-school-education-a-profound practice/

Smallwood, J. (2013). Distinguishing how from why the mind wanders: A process–occurrence framework for self-generated mental activity. *Psychological Bulletin*, *139*(3), 519–535. https://doi.org/10.1037/a0030010

Smallwood, J., Baracaia, S. F., Lowe, M., & Obonsawin, M. C. (2003). Task unrelated thought whilst encoding information. *Consciousness and Cognition, 12*(3), 452–484.

https://doi.org/10.1016/s1053-8100(03)00018-7

Smallwood, J., Fishman, D. J., & Schooler, J. W. (2007). Counting the cost of an absent mind: Mind wandering as an underrecognized influence on educational performance. *Psychonomic Bulletin & Review*, *14*(2), 230–236. https://doi.org/10.3758/bf03194057

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: empirically navigating the stream of consciousness. *Annual Review of Psychology*, *66*(1), 487–518. https://doi.org/10.1146/annurev-psych-010814-015331

Smith, E. N. (2023, March 2). *Yoga focus and the wandering mind*. YogaUOnline. https://yogauonline.com/yoga-health-benefits/yoga-for-stress-relief/yoga-focus-and-the wandering-mind/#:~:text=The%20action%20of%20positive%20focus,doubt%20and%20step%20into%20possibility

Srinivasan, N., & Baijal, S. (2007). Concentrative meditation enhances preattentive processing: a mismatch negativity study. *NeuroReport*, *18*(16), 1709–1712. https://doi.org/10.1097/wnr.0b013e3282f0d2d8

Stawarczyk, D., Majerus, S., Maj, M., Van Der Linden, M., & D'Argembeau, A. (2011). Mind-wandering: Phenomenology and function as assessed with a novel experience sampling method. *Acta Psychologica*, *136*(3), 370–381. https://doi.org/10.1016/j.actpsy.2011.01.002

Stone, M. (2018). *The Inner Tradition of Yoga: A Guide to Yoga Philosophy for the Contemporary Practitioner.*

Subramanya, P., & Telles, S. (2009). Effect of two yoga-based relaxation techniques on memory scores and state anxiety. *BioPsychoSocial Medicine*, *3*(1), 8. https://doi.org/10.1186/1751-0759-3-8

Susac, A., Bubic, A., Vrbanc, A., & Planinic, M. (2014). Development of abstract mathematical reasoning: The case of algebra. *Frontiers in Human Neuroscience, 8*. https://doi.org/10.3389/fnhum.2014.00679

Suzuki, H., Hayashi, S., Murakami, S., & Nobori, H. (2021). Effects of yoga practice as mindfulness training on mind wandering and psychological state. *International Journal of Exercise Science, 4*(1), 16–21. https://doi.org/10.51039/ises.4.1_16

Swanson, H. L., & Beebe-Frankenberger, M. (2004). The relationship between working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology, 96*(3), 471–491. https://doi.org/10.1037/0022-0663.96.3.471

Swanson, H. L., & Sáez, L. (2003). Memory difficulties in children and adults with learning disabilities. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of learning disabilities* (pp. 182–198). The Guilford Press. https://psycnet.apa.org/record/2003-02238-010

Szpunar, K. K., Moulton, S. T., & Schacter, D. L. (2013). Mind wandering and education: From the classroom to online learning. *Frontiers in Psychology, 4*, 58178. https://doi.org/10.3389/fpsyg.2013.00495

Tang, Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., Yu, Q., Sui, D., Rothbart, M. K., Fan, M., & Posner, M. I. (2007). Short-term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences of the United States of America, 104*(43), 17152–17156. https://doi.org/10.1073/pnas.0707678104

Telles, S., Singh, N., Bhardwaj, A., Kumar, A., & Balkrishna, A. (2013). Effect of yoga or physical exercise on physical, cognitive and emotional measures in children: a randomized controlled trial. *Child and Adolescent Psychiatry and Mental Health, 7*(1), 37. https://doi.org/10.1186/1753-2000-7-37

Thakur, R. K. (2020, May). *Maths Education in India: Policy and reality*. Teacher Plus. https://www.teacherplus.org/maths-education-in-india-policy-and-reality/

Tyagi, K., Rane, C., Harshvardhan, & Manry, M. (2022). Regression analysis. In R. Pandey, S. K. Khatri & P. Verma (Eds.), Artificial *Intelligence and Machine Learning for EDGE Computing* (pp. 53–63). Elsevier. https://doi.org/10.1016/b978-0-12-824054-0.00007-1

Unick, J. L., Dunsiger, S. I., Bock, B. C., Sherman, S. A., Braun, T. D., Hayes, J. F., Goldstein, S. P., & Wing, R. R. (2023). A randomized trial examining the effect of yoga on dietary lapses and lapse triggers following behavioral weight loss treatment. *Obesity Science & Practice*, *9*(5), 484–492. https://doi.org/10.1002/osp4.678

Upadhyah, A., Pandit, D. P., Goyal, P., & Sharma, D. (2019). Effect of short term yoga on body weight,

BMI, body fat percentage & blood pressure. *Indian Journal of Clinical Anatomy and Physiology*, *6*(2), 179–182. https://doi.org/10.18231/j.ijcap.2019.040

Vago, D. R., & Zeidan, F. (2016). The brain on silent: mind wandering, mindful awareness, and states of mental tranquility. *Annals of the New York Academy of Sciences, 1373*(1), 96–113. https://doi.org/10.1111/nyas.13171

Van Aalst, J., Jennen, L., Demyttenaere, K., Sunaert, S., Koole, M., Ceccarini, J., & Van Laere, K. (2021). Twelve-Week Yoga vs. Aerobic Cycling Initiation in Sedentary Healthy Subjects: A Behavioral and Multiparametric Interventional PET/MR Study. *Frontiers in Psychiatry*, *12*. https://doi.org/10.3389/fpsyt.2021.739356

Vannucci, M., Chiorri, C., Nocentini, A., & Menesini, E. (2020). Distinguishing spontaneous from deliberate mind wandering in adolescents: The role of attentional control and depressive symptoms. *British Journal of Developmental Psychology*, *38*(3), 434-441. https://doi.org/10.1111/bjdp.12325

Vestergaard-Poulsen, P., van Beek, M., Skewes, J., Bjarkam, C. R., Stubberup, M., Bertelsen, J., & Roepstorff, A. (2009). Long-term meditation is associated with increased gray matter density in the brain stem. *NeuroReport, 20*(2), 170–174. https://doi.org/10.1097/wnr.0b013e328320012a

Voss, S., Cerna, J., & Gothe, N. P. (2022). Yoga impacts cognitive health: neurophysiological changes and stress regulation mechanisms. *Exercise and Sport Sciences Reviews, 51*(2), 73–81. https://doi.org/10.1249/jes.0000000000000311

Wagenmakers, E., Van Der Maas, H. L. J., & Grasman, R. P. P. P. (2007). An EZ-diffusion model for response time and accuracy. *Psychonomic Bulletin & Review*, *14*(1), 3–22. https://doi.org/10.3758/bf03194023

Wang, J., Conder, J. A., Blitzer, D. N., & Shinkareva, S. V. (2010). Neural representation of abstract and concrete concepts: A meta-analysis of neuroimaging studies. *Human Brain Mapping, 31*(10), 1459–1468. https://doi.org/10.1002/hbm.20950

Wang, D., & Hagins, M. (2016). Perceived Benefits of Yoga among Urban School Students: A Qualitative Analysis. *Evidence-based Complementary and Alternative Medicine, 2016*, 8725654. https://doi.org/10.1155/2016/8725654

Waters, L., Barsky, A., Ridd, A., & Allen, K. (2014). Contemplative education: A systematic, evidence-based review of the effect of meditation interventions in schools. *Educational Psychology Review, 27*(1), 103–134. https://doi.org/10.1007/s10648-014-9258-2

Wen, Z. E., & Jackson, D. O. (2022). Working Memory. In *The Routledge Handbook of Second Language Acquisition and Individual Differences* (1st ed.). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003270546-5/working-memory-zhisheng-edward-wen-daniel-jackson

Wiggins, H. Z. (2022, December 21). *Mathematics: Forget simplicity, the abstract is beautiful - and important*. The Conversation. https://theconversation.com/mathematics-forget-simplicity-the-abstract-is-beautiful-and-important-91757

Xie, R., & Xu, L. (2024). The neural mechanisms behind mind wandering phenomenon: A brief review. *International Journal of Frontiers in Sociology, 6*(4). https://doi.org/10.25236/ijfs.2024.060414

Yadav, A., Verma, S., Panwar, M., & Yadav, N. K. (2022). Role of Yoga practices on cognitive functions. *International Journal of Health Sciences, 6*(S3), 3288–3304. https://doi.org/10.53730/ijhs.v6ns3.6341

Yadav, K., Yadav, A., & Singh, S. (2022). Yoga and attention: A systematic review. *Yoga-Mimamsa, 54*(2), 128. https://doi.org/10.4103/ym.ym_66_22

Yanko, M. R., & Spalek, T. M. (2013). Driving with the wandering mind: The effect that mind-wandering has on driving performance. *Human Factors, 56*(2), 260-269. https://doi.org/10.1177/0018720813495280

Yordanova, J., Kolev, V., Nicolardi, V., Simione, L., Mauro, F., Garberi, P., Raffone, A., & Malinowski, P. (2021). Attentional and cognitive monitoring brain networks in long-term meditators depend on meditation states and expertise. *Scientific Reports, 11*(1). https://doi.org/10.1038/s41598-021-84325-3

Zanesco, A. P., King, B. G., MacLean, K. A., Jacobs, T. L., Aichele, S. R., Wallace, B. A., Smallwood, J., Schooler, J. W., & Saron, C. D. (2016). Meditation training influences mind wandering and mindless reading. *Psychology of Consciousness: Theory, Research, and Practice, 3*(1), 12–33. https://doi.org/10.1037/cns0000082

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition, 19*(2), 597–605. https://doi.org/10.1016/j.concog.2010.03.014

Zheng, Y., Wang, D., Zhang, Y., & Xu, W. (2019). Detecting Mind Wandering: An Objective Method via Simultaneous Control of Respiration and Fingertip Pressure. *Frontiers in Psychology, 10*, 419803. https://doi.org/10.3389/fpsyg.2019.00216